Environmental and Regulatory Issues Relating to the Utilization of Produced Water from Oil and Gas Operations

Final Report for the Environmental and Regulatory Issues Relating to the Utilization of Recycled Produced Water from Oil and Gas Operations:
1: A Study of Existing Policies of State and Federal Agencies
2: Development of an Approved Program for Re-Use of Water Objectives of Project during the Period 05/15/2001 to 09/30/2002

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Management Abstract

Management and disposal of produced water is one of the most challenging problems associated with the oil and gas industry. Very large volumes of produced water, or brine, are produced along with the oil and gas resources. The current management methods available, such as reinjection of the produced water, are costly to the industry and the environment. The management of produced and injected water is a major emphasis in the industry today. There are various water issues in the industry as well, such as treatment of wastewater, its effects on the environment, and a growing concern for the availability of water in arid lands.

The project is a study of the existing policies of two oil and gas producing regions. We have been working with federal and state agencies to develop guidelines for companies to follow for making this new source of fresh water available for productive use. We have met with appropriate agencies as new rules and regulations are considered and work with those seeking to remove some of the roadblocks to the re-use of treated produced water.

The following is a report of the research completed for this project. The report includes a discussion of results, accomplishments, and conclusions that have been reached concerning the environmental and regulatory issues relating to the utilization of produced water from oil and gas operations. We have also produced a roadmap of the steps needed to get this technology accepted by the public and the regulatory community.

Our first work was directed toward identifying the agencies and regulatory practices that are encountered when developing a produced water reuse program. The Texas A&M Produced Water Treatment Project has been used as an example of the type of project that operators would plan. The A&M program utilizes fresh water resources obtained from produced water treatment to restore native rangelands.

In 2002, we have focused on the specific steps a company would take in developing a project. This step includes a description of our group's work in creating a project in West Texas. We have developed a preliminary set of guidelines that companies can use as a roadmap to integrate a fresh water resource recovery program into their own produced water management program.

Finally we have developed a reference contact list. Agencies we have contacted were collected in a database for members of the SWC. The database contains contact information on state and national officials, water treatment companies, and individuals involved with these types of programs nation-wide. With our work specific to Texas, we have been coordinating with the Texas Railroad Commission, the regulatory authority for our state. The final portion of the project involves the establishment of information on the Texas A&M GPRI web site describing the water project (http://www.gpri.org).

Final Report

Environmental and Regulatory issues Relating to the Utilization of Produced Water from Oil and Gas Operations

I. Introduction

Impending Environmental Problems Facing the Oil & Gas Industry

A water crisis is looming in many parts of the United States. Areas in the American West and Southwest are especially critical, with many areas currently coping with a series of droughts that have significantly altered land-use behavior and impacting both urban and rural communities. Throughout these regions, water quantity and quality issues increasingly are being recognized by state policy makers, local elected officials, and the citizenry at large. In Texas, data available from the Cooperative Extension (TCE) show the pervasiveness of these concerns in the state (TCE 1999). In 1999, TCE, in a major planning effort, gathered information from over 10,000 Texas residents on critical issues confronting their communities. Those issues associated with water quantity and quality ranked among the top five priorities in 184 of the state's 254 counties (TCE 1999). It is apparent that solutions to the pressing water quantity and quality issues in Texas and other states will require innovative approaches and technologies.

A photograph of the O. C. Fisher reservoir near San Angelo Texas shows the effect of the extended drought on the city's water supply. Until summer rains in 2002 came, the reservoir was at less than 15% capacity.

Another serious water related problem faces the oil and gas producers in many of the same areas of the country. Oil and gas production is a major industry in many of the drought affected areas. A major problem for these companies revolves around the production and disposal of large quantities of water, mostly brine. Public records obtained from the Railroad Commission of Texas reveal that every day more than 400 million gallons of water are produced from oil and gas wells in the Permian Basin region of West Texas. For every barrel of oil that is produced in the region, 300 gallons of water are produced. Oil and gas companies only use about one percent of this produced water; the remaining 99% is typically disposed of through re-injection.

In Wyoming, the production of natural gas from coal beds on state and federal land is an extremely contentious issue because of the co-production of water[1]. According to the Bureau of Land Management, the average production of a coal bed methane (CBM) well is 125,000 cfd of gas and 12 gpm of water (Powder River Basin Resource Council 2002).

Water produced from a CBM well is shown overflowing a holding tank on a ranch in Wyoming (photo courtesy of New York Times[1]).

In other words, gas producing companies must manage more than 17,280 gallons of produced water per well every day. The petroleum industry and the regulatory agencies have managed this produced water as if it were a pollutant to be disposed of according to standard disposal practices. The public sees this disposal as a waste of water resources. The result? The EPA has just denied permits to the development of the natural gas resources.

In Appalachia, while not as critical, produced water management is still a significant expense of operators and while the issues facing eastern operators may be different, resolution of the problems are similar.

Beginning to Address the Problems

Controversy will continue to exist wherever CBM production is planned or where produced water from conventional oil and gas production becomes more and more difficult to manage. Recognizing that an equitable solution is urgently needed, the oil and gas sector, lawmakers and regulatory agencies are studying ways to resolve the conflicting interests of the stakeholders in the drama. In 2002, there were numerous meetings to bring together those who could effect changes in the industry.

Most industry groups recognize that technology exists to remove contaminants from produced water and to create a resource that could be used to supplement current water supplies in water-short regions. New Mexico groups are leading the way in legislative action. Texas A&M's Texas Water Resources Institute (TWRI) is in the forefront of technology development with two field demonstration projects in Texas to utilize fresh water recovered from oil field brine to rehabilitate rangelands and wildlife habitats.

The solution to the problem is for all groups to realize that produced water is a resource not a pollutant and that wise management of the resource will bring about increased revenue to operating companies, more fresh water resources for the public sector and less burden on the regulatory agencies who are responsible for oversight of oil and gas and the environment.

A Role for the Stripper Well Consortium

Regulations[2-5] governing the disposal of produced water have become more stringent over the years. Discharge of produced water is not allowed on land and in streams and rivers where the produced water can come in contact with the surface water. At the present there are no clear-cut laws and regulations in the United States dealing with the beneficial use of produced water. The SWC can become one of the advocates of change as these agencies react to new technology and new environmental imperatives.

The SWC represents a voice of the independent producer. Being technology oriented, the SWC can serve as a champion of new practices and processes that benefit the independent. This study by Texas A&M, funded by the SWC is the first step on the way to gaining acceptance of the concept of value placed upon produced water. The following report will review technology to recover fresh water from produced brine and show the potential benefits that could be derived from the development of this resource. The study will describe our efforts to identify ways to get projects to the field. We will show how (and why) local, state and federal agencies regulate this activity and will present suggestions for ways that members of the SWC can influence changes in these agency's actions to make beneficial use of produced water easier to achieve.

II. Fresh Water Resources from Oil Field Waste

Types of Beneficial Uses: Environmental Impacts

This report discusses water management options specific to independent operators. There are many opportunities for using produced water. However, the ability to identify an alternative as being feasible will likely be dependent upon very site-specific and situation-specific criteria. Fresh water resource recovery from produced water is the example cited in our work, but many other options are available. Options such as produced water impoundment and release, re-injection into fresh water aquifers, and resource recovery all being considered by our industry and field demonstrations are being planned by a number of groups..

Several impediments to the widespread adoption and diffusion of water treatment technology such as the TWRI program must still be addressed. . Discharge of produced water to the surface waters and seawaters is prohibited under the Clean Air and Water Act until certain criteria are met.[4,5] There are no market mechanisms and incentives currently in place for the oil and gas operators to treat water and make it available as a commodity. Oil and gas companies produce petroleum, not fresh water. They see the water produced with petroleum as a waste, not a byproduct to be re-used. It will be necessary to work with industry associations and governing bodies to identify ways to solve the problem.
However, even if oil and gas companies began producing treated water, we do not know the extent to which individuals would be willing to accept its use.

Field operations are the best way to measure the performance of the GPRI units. A number of sites are to be established in different locations so as to evaluate performance over a range of conditions including types of produced water, types of terrain and types of volumes.

The program involves environmental monitoring of test plots where natural rainfall is augmented though the use of fresh water produced by portable water treatment modules. The field project is expected to show that native grasses can be re-established in degraded areas safely at a rate more than 8 times faster than comparable methods of rangeland restoration.

Ultimately the success of brine treatment will depend upon the cost of the treatment process and whether it is comparable to the cost of brine disposal and to the cost of fresh water from other sources. Tests on components of the filtration modules have shown that brines with TDS less than 10,000 ppm can be treated and converted to fresh water of 500 ppm or less for a cost of approximately $01.0 per gallon[6]. Our goal is to reduce this cost by at least 50%. We also expect to extend the capability of the units to be able to treat brines of up to 50,000 TDS as the program proceeds.

While treatment of produced water is not new, there have been few projects where the use of the re-used water has been carefully monitored. For this project, the Texas Water Research Institute has established a task force of scientists from the Rangeland and Ecology Management Department to design, implement, and monitor discharge from the GPRI water treatment modules.

The plan is to augment the natural rainfall at a field site in a systematic manner established by hydrologists, soil scientists and rangeland rehabilitation specialists. Control sites near the treatment site will be used as baseline comparisons. One site will be monitored but otherwise no intervention is planned. The second site will augment natural rainfall with added water from a fresh water source.

The third test site will be using the same amount of added water obtained from the GPRI modules. A monitoring program is to be established by Dr. John Bickham of the Department of Wildlife and Fisheries, a noted authority on environmental toxicology.

It is important to note that the rules and regulations relating to impoundments and the CBM industry in the West are currently being modified or developed for several states. Reviewers who can provide regulatory clarification or updates to the regulatory section of this document would be appreciated.

Regulatory agencies are accustomed to handling "impoundment" projects. Impoundments represent a single management option or a combination of management options including: livestock and wildlife watering from wetlands, fisheries and recreational ponds, recharge and evaporation ponds or other combinations. Specific applications, regulations, and limitations are associated with each impoundment type. Regional limitations derived naturally from insufficient water quality, climate, or methane production prevent anyone from establishing any "universal" guidelines.

The impoundment of produced water from CBM production, for instance, can be an option utilized by operators as part of their water management practice. In some producing basins, such as the Powder River Basin, impoundments play a large role in water management practices, while in other basins impoundments may only be used during drilling operations. The impoundment of CBM water is the placement of water produced during operations at the surface in a pit or pond. There are a variety of ways in which operators can impound produced water at the surface. Impoundments can be constructed on or off channel and the regulatory authority in some states varies based on whether the impoundments are off or on channel.

Impoundments can be used for a variety of water management options including, disposal by evaporation and/or infiltration, storage prior to another water management option including injection or irrigation, or for beneficial use such as a fishpond, livestock and wildlife watering ponds or a recreational pond. The impoundment of water can be performed in any area where there is sufficient construction space. In areas with limited rainfall or drought conditions, impoundments could be used to recharge groundwater in shallow alluvial and coal seam aquifers, to provide livestock and wildlife water or for the storage of water prior to irrigation.

As stated, economics of produced water treatment depends on many factors. These factors include the amount of suspended and dissolved hydrocarbons present in the produced water, amount of suspended and dissolved solids (salts) present in the produced water[7]. Cost of treating the produced water also depends on the final quality of the permeate (treated water) that is required by treating the produced water (final TDS in the produced water).

One of the most important factors affecting the cost of treating the produced water is the amount of total recovery from produced water that is required. As the amount of recovery is increased, the operating and the capital costs increase because of the higher pressure required for higher recoveries (equipment becomes more expensive). At the same time the operating and capital cost per gallon of water treated/recovered and may go down. There is a fine balance involved in deciding the amount of water to be recovered and the minimum treated water price. This involves an optimization process with actual field testing of the water treatment module to determine the actual operating conditions for most economical treatment price for produced water treatment.

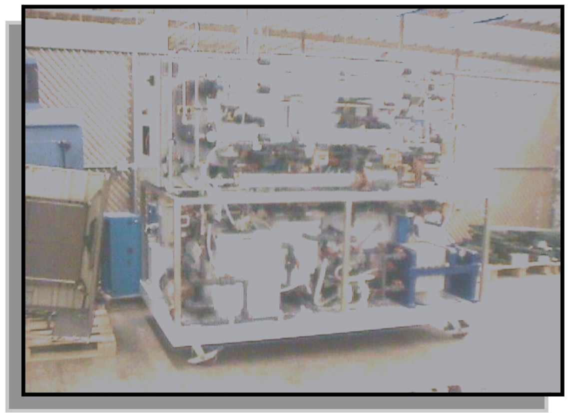
A&M Fresh Water Resources Development Program

At Texas A&M a number of scientists and engineers are working on creating new fresh water resources from oil field waste brines. These tasks are coordinated by TWRI and the Department of Petroleum Engineering [8,9].

Funding from the GPRI project will be used to design and construct field filtration modules. The GPRI modules will utilize a two-step pre-filtration step followed by two membrane filtration steps, the last being a reverse osmosis (RO) unit to remove the dissolved salts from the brine stream.

Each module is designed to treat a portion of the produced water stream for a specific field site with the reject from the RO unit being added back to the remaining produced water disposal system. Depending on the efficiency of the filtration modules, the units will be able to deliver up to 2,000 gallons per day of fresh water having less than 500 ppm total dissolved solids (TDS). The units will be placed near oil field production batteries to treat water on site to use nearby in rangeland reclamation.

Testing to select the types of pre-filtration and the type of filters best suited for treating the brine are being performed using produced brine collected from a Grimes County oil field disposal facility. Input waste streams had approximately 200 ppm crude oil in a 15,000 TDS brine. Pre-filtration reduced the brine to less than 20 ppm. Filtration and RO treatments with different types of filters results in separation efficiency of from 75% to 95% (one-pass). Optimization tests are underway to find a filter media that will maximize flux and filtration efficiency for any given oil field brine type saline system.



This picture shows a modular wastewater filtration unit that would be modified to place at a production battery. . Portable RO membrane filtration units have the capacity to recover from 1,000 to 5,000 gallons a day from oil field brine.

Plans are being made to employ the GPRI units in a number of field sites to test their efficiency and to evaluate the best combinations of pre-treatment and filter types to use for a particular type of produced brine. Presently we expect to have field sites in Texas, New Mexico, and Wyoming at GPRI sponsor's fields.

The unit's performance will be measured by their filtration efficiency, the amount and quality of the fresh water produced, and the operating costs of the units. Units will be operated over extended time periods. By monitoring the performance of the units over a range of operating conditions, and optimizing pre-filtration and filtration techniques, we expect to be able to reduce operating costs and increase filtration efficiency substantially during field operations. Water treatment with the GPRI units will be carefully monitored to measure the efficiency of the removal of hazardous material and deleterious salts.

III. Regulations on Use of Produced Water

Produced water is saltwater or brine that is produced along with hydrocarbons during the exploration and production processes of the petroleum industry. In some cases, the volume of water produced may exceed the volume of hydrocarbon production. The disposal of this water becomes costly to the industry. Discharge of produced water to the surface waters and seawaters is prohibited under the Clean Air and Water Act until certain criteria are met. The maximum allowable amount of petroleum hydrocarbons in produced water that can be discharged is 29 ppm. Discharge of produced water is not allowed on land and in streams and rivers where the produced water may come in contact with surface water.

Classification of Discharged Brine

The disposal of produced water is regulated by the U. S. Environmental Protection Agency (EPA), **http://www.epa.gov.** In many states the responsibility for monitoring and enforcing EPA regulations is suborned to state oil and gas regulatory agencies. Recognizing that the potential impact of produced water disposal varies, the EPA recognizes several sub categories of disposal options. One of these is the "beneficial use" category. These regulations are based on available technology and as technology changes, the regulations may vary.

The most influential regulation affecting a new beneficial use program for oil field produced water is the 1972 Federal Water Pollution Control Act. Together with a corresponding regulation known as the National Pollution Discharge Elimination System (NPDES), these programs control what quality water be released into the environment. As technology developments open the door to new waste water treatment, these basic regulations will be modified, but only after testing and demonstration of the beneficial effects to the community and the environment.

EPA Regulations

40 CFR 435, the Oil and Gas Extraction Point Source Category, Subpart C Onshore Subcategory, establishes there shall be no effluent discharge of produced waters. However, Subpart E-Agricultural and Wildlife Water Use, allows the discharge of produced water for agricultural or wildlife watering use if the facility is located west of 98' meridian. Under this subpart, the water must be of good enough quality to be used for wildlife, livestock, or agricultural use and that the water be put to such use during periods of discharge.

40 CFR 435 is only applicable when State authorities deem CBM produced water as an oil and gas produced water. The State of Alabama, for example, does doe consider CBM produced water as an oil and gas extracted water and thus, is not regulated by this standard. Currently the EPA does not have CBM specific produced water effluent limitations since 40 CFR 435 was promulgated prior to initiation of current CBM operations. Section 307 (a)(1) of the Federal Water Pollution Control Act, as amended, however, does require a list of toxic pollutants and effluent standards for cyanide, cadmium, and mercury when applicable. Produced water from the Oil and Gas industry is exempt from EPA RCRA rules and standards and is therefore, not subject to 40 CFR, Part 264, which establishes performance standards for hazardous waste landfills, surface impoundments, land treatment units, and waste piles. If State authorities due or were to classify produced water as a hazardous waste *and* also deem the water as a non bi-product produced by the oil and gas industry, the above mentioned standard would apply..

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The Water Permits Division (WPD) within the U.S. Environmental Protection Agency's Office of Wastewater Management manages the NPDES permit program in partnership with EPA Regional Offices, states, and tribes. NPDES permitting requirements for produced water will vary from state to state, but in general would largely depend on the quality of water and eventual use of the water. Appropriate state water quality authorities would need to be contacted to ascertain their permitting requirements.

Water Problems Caused in Part by Conflicting Regulations

Management and disposal of produced water is one of the most significant problems associated with the oil and gas industry. In Texas, more than 150,000,000 gallons of water are produced in the industry each day. The management and disposal of this water becomes very costly to the industry, as well as becoming a possible reservoir and environmental hazard. The current method commonly used throughout the petroleum industry today is reinjection of the water produced during exploration and production. This costs up to $1.30 per barrel of produced water. The preferred method for the disposal of produced water is one that adequately protects the environment and is of the lowest cost to the operator. Regulatory and monetary constraints often limit the options available, however.

The Texas Natural Resource Conservation Commission (TNRCC) estimates that by the year 2020, fresh water needs in the state of Texas will increase by more than twenty times. There are many arid regions, such as West Texas, with little fresh water resources, but with large amounts of oil, gas, and brine production. According to the Texas Railroad Commission, an excess of 400 million gallons of water are produced from oil and gas wells in the Permian Basin of West Texas with only one percent of the produced water being used at the well locations. The remaining 99% is disposed of by reinjection. The oil and gas industry is now looking into ways of using the vast amounts of produced water to benefit these areas in which a scarcity of water exists. With new technologies in the oil and water separation and desalination processes, contaminants may be removed from produced water. This produced water may also be treated and converted into reuse quality for beneficial purposes, such as agricultural, rangeland and grassland restoration, site remediation, landscape watering, or water for oil field use. Presently, there are no clear-cut laws and regulations in the United States dealing with the beneficial use of produced water.

The vast amounts of produced water along with natural gas is not only an issue in Texas, but in other states as well. Another uprising concern in the industry is the production of coal bed methane (CBM) along with water production, as found in Wyoming. According to the Bureau of Land management and the Powder River Basin Council of 2002, the average production of a CBM well is 125,000 cubic feet per day of gas and 12 gallons per minute of water. This exceeds over 17, 280 gallons per well of produced water with extremely high disposal expenses that must be managed daily along with the gas production.

The environmental effects of water disposal is a critical issue in all states of the U.S. It is much better to address environmental concerns early in a program than to be confronted to angry landowners or other concerned public representatives.

There currently exists a need for alternate methods of managing oil and gas produced water. The technology to remove contaminants from the produced water and create a new water resource is available. By working with the Texas A&M Department of Rural Sociology, the Rangeland Ecology and Management Department, as well as the Petroleum Engineering Department at Texas A&M, we have found that there are no market mechanisms and incentives currently available to the oil and gas industry to treat their produced water and make it available as a commodity. Secondly, we have to make the general public, as well as the industry, become aware of the technologies available and the benefits of using this technology to create a new water resource.

The photograph shows a managed test plot at the Mason Wildlife Management Area in West Texas. Agri-scientists use these plots to evaluate native grasses development, soil characteristics, hydrology of rainfall events.

IV. State and National Stakeholder Agencies

State Agencies

In New York, our SWC contact is John Martin of the New York State Environmental Development Authority (NYSERDA). NYSERDA is one of the sponsors of this project and through John will work to facilitate a field demonstration if an opportunity arises. In addition, through the IOGCC I was able to meet Bradley J. Field, Director of the Department of Environmental Conservation, Division of Mineral Resources, I briefed Mr. Field and have provided both him and John Harmon, the Deputy Director, a summary of our A&M beneficial use project. Opportunities for beneficial use projects may be limited. On the other hand, any successful project demonstrations would provide these agencies with valuable information to aid in the consideration of a future project.

For beneficial use projects in Pennsylvania the appropriate contact is the Department of Environmental Protection, Pennsylvania Bureau of Oil & Gas Management. Mr. James E. Erb is the Director. I met with Mr. Erb at an IOGCC meeting and briefed him on the project and provided him with a summary of the A&M program. Note that any possible projects in Pennsylvania will have the benefit of Penn State personnel to partner with A&M and company engineers in planning and operations.

In Texas the Railroad Commission regulates oil and gas activities. Railroad Commission of Texas: The Energy Operations Division Director is Ronald L. Kitchens, phone 512/463-7068; fax 512/463-7000 Michael Williams, one of three Commissioners has personally endorsed the concept of beneficial use projects and is knowledgeable about the technology being offered by Texas A&M. His deputy who coordinates the A&M projects is Bryndan Wright ((512) 463-7145). Texas offers the most opportunity for beneficial use projects. With the backing of the Chairman of the RRC, and the presence of A&M research centers throughout the state, any company interested in a project will have ample assistance.

In Oklahoma the agency responsible for oil and gas regulation is the Oklahoma Corporation Commission Oklahoma Corporation Commission: A good contact at the OCC is Michael L Decker, Deputy General Counsel ((405) 521-4258. He is involved with produced water discharge projects in Oklahoma and is working to draft new guidelines for beneficial use projects. Also in Oklahoma, the state Marginal Well Commission, a member of the SWC serves as a clearing house of key issues affecting independents. It is likely that a beneficial use project will be able to obtain permits necessary to implement any sound program.

A shortcut to all of these key individuals is provided by the A&M Fresh Water Resource Recovery Center is to use the contact information in our companion document that lists individual names, agency and contact information for each of the Stripper Well Consortium states.

National Agencies

As stated earlier, issues related to produced water management in individual states may also fall within the jurisdiction of state departments of environmental quality. One way to access the agency in a particular is through the EPA web site gateway at http://www.epa.gov/epapages/statelocal/envrolst.htm. These can give contact information necessary to begin the permitting process.

A national association that addresses state produced water issues in the Groundwater Protection Council http://www.gwpc.org. The GWPC is a national association of state ground water and underground injection control agencies that work to promote the protection and conservation of ground water resources for beneficial uses. Recognizing that fresh water recovered from oil field produced water will come in contact with ground water, the GWPC has established committees to address theses issues. As stated in their mission declaration, The Ground Water Protection Council provides a forum for stakeholder communication and research in order to improve governments' role in the protection and conservation of ground water."

One of the agencies that represent state interests is the Interstate Oil & Gas Compact Commission (IOGCC). This group represents the governors of **37 states** -- 30 members and seven associate states -- that produce virtually all the domestic oil and natural gas in the United States. The organization was established by the governors in 1935 and is among the oldest and largest interstate compacts in the nation.

The IOGCC assists states in addressing such issues as -- maximizing domestic oil and natural gas production, minimizing the waste of irreplaceable natural resources, and protecting human and environmental health -- through sound regulatory practices. It serves as the governors' collective voice on oil and gas issues and advocates states' rights to govern the petroleum resources within their borders. Regulatory coordination and government efficiency are among the IOGCC's long-standing interests.

Because of its unique structure, the IOGCC offers a highly effective forum for government, industry, environmentalists and others to share information and viewpoints, allowing members to take a proactive approach to dealing with emerging technologies and environmental issues. The organization is known internationally for significant contributions to oil and natural gas regulation and conservation practices.

The Internet link to IOGCC is http://www.iogcc.state.ok.us/. Anyone interested in can go to the site and select their state to link to regulatory agency responsible for oil and gas issues and to get contact information for their state's representatives.

A shortcut to all of these key individuals is provided by the A&M Fresh Water Resource Recovery Center is to use the contact information in our companion document that lists individual names, agency and contact information for each of the Stripper Well Consortium states.

V. Coordination to Effect Change in Regulations and Provide Benefits to the Environment

Role of the SWC

All of the states represented in the SWC will have various agencies with jurisdiction over new beneficial uses of produced water projects. It is necessary to coordinate efforts to streamline and simplify permitting so that such projects can be planned and implemented. The independent producer through the SWC has a strong voice in future directions of our agencies that govern oil and gas production in the U.S. and

Role of the Industry

The first step we as an industry have to take is to accept the fact that produced water can be a resource when properly treated and used for beneficial purposes. Once we see that we have a potential resource, we can work to set a value for the resource and to use it for projects to improve the environment, not harm it.

A&M's Role

Texas A&M is undertaking a number of steps to support fresh water resource recovery technology development. We are planning a new interdisciplinary program at the masters and doctorial level in water management. TWRI is our sponsor of our fresh water recovery and utilization program for oil field activity. And our group is available to assist others in creating new field demonstrations of technology that would further the cause of sustainable development related to fresh water resources.

VI. Results of SWC Project

We have reviewed the regulatory issues that a producer would encounter when planning a produced water resource recovery program. This final report summarizes the existing policies of state and federal agencies and recommends development of an approved program for re-use of water. The recommended program includes establishing a dialog with the local community and the regulatory agencies prior to planning a project. To facilitate new projects, Texas A&M offers its services at no cost to companies considering a project. Following are components of this research that can be used to help plan projects.

Contact List Database

A working contact list has been created for members of the SWC and will be maintained for the next six months. The list contains names of those individuals at agencies we have contacted. The database contains contact information on state and national officials, water treatment companies, and individuals involved with these types of programs nation-wide. Our complete database is included in the **Appendix** following this report.

Program Changes in Southwest U.S.

As a result of several meetings with the Texas Railroad Commission, our group has successfully gained its support in this project. Chairman Michael L. Williams of the TRRC visited Texas A&M endorsing our produced water research program[10]. Chairman Williams committed to help the project along by reviewing the state's regulations governing the reuse of treated oilfield produced water and determining what changes can be made to increase water availability. Williams has also pledged to help find funding for this particular program and to encourage oil and gas producers in Texas to support field demonstration. A copy of the letter of support from Chairman Williams and the Texas Railroad Commission is included in the URL listed in reference 10.

Program Changes in Eastern U. S.

In the Eastern U.S. where water is not as critical an issue, regulatory changes will be more gradual. The best way to effect change will be to find examples of successful projects that exemplify good science and careful operation. It is recommended that the SWC continue to be active in this area and serve as a spokesman for the independent producer whose livelihood is at stake.

A Prototype Program

VII. Roadmap to Acceptance: Recommendations for Further Work

There are five critical steps that need to be taken to demonstrate that oil field produced water has value and can be used for beneficial purposes.

Five Step Check List

For every field operation the operator must address the following:

1. Identify the resource. Where is the produced water coming from? How regular is the volume produced? How much water is being produced? How difficult is it to remove the contamination from the brine? What volume of "reject" water is produced along with the fresh water? How long will the waste stream be produced? These are some of the basic questions to be addressed by the operator. It is also important to identify a use for the resource so that the proper process design and monitoring program can be selected early in the design of the project. These questions need to be addressed in an organized and complete manner. We recommend that further work be done to organize the steps necessary to identify resources and estimate costs of recovering fresh water from that resource.

2. Engage the local community and the regulatory agencies. What can be done with the produced water? Do individuals in the area have a need for the fresh water? Is there a question about the environmental impact of the project? This type of the size of the treatment facility be of sufficient capacity to supply the water needed for a project. Consider the potential impact on the community –both positive and negative. We recommend that future field demonstrations of fresh water recovery include an industry-community dialog

3. Plan a project that is compatible with the environment and offers value to all stakeholders. Enlist the regulatory agencies. Learn the agency contacts for your area and show by example that a well-designed program will be beneficial to the area not a liability.

4. Demonstrate the program and monitor results. Field operations are a must if realistic determinations of cost and efficiency are to be demonstrated. Accurate monitoring of field operations will not only provide documentation of the correct operating practices but will also provide information that can be used for subsequent projects in other areas. For example, each of the test sites and the control sites of our Texas A&M beneficial use projects will be monitored for the growth of plant life and the presence of wildlife. A biochemical monitoring program will be established using state of the art DNA biotyping. Using results from the sampling program over an extended time period, tests the hypothesis that no environmental effects will be observed between the fresh water augmented sites and the treated produced water sites.

5. Report results. It will be imperative that field operations be described fully. Even if results are disappointing, test results from field operations are critical to improving design of treatment units and in changing operating practices.

Project Assistance Service Offered by Texas A&M

Any company willing to undertake a field demonstration of the use of fresh water resources from produced brine can contact us at Texas A&M. We will work, at no cost, to assist in creating field demonstrations. If A&M technology is requested we will work with your company to get supplemental funding from state or federal governmental agencies.

A&M Future Activities

Texas A&M University, through the Department of Petroleum Engineering is planning field demonstrations of the fresh water recovery process in a number of locations. The SWC will be asked to fund one of the field demonstrations in 2003 and 2004. In addition, we are working with partners who are providing pre-treatment technology crucial to oil field brine treatment. The Department's oil field brine treatment program is a part of a University wide effort to address water management, fresh water resource recovery and beneficial use of water resources in a comprehensive, multi-disciplinary program. A new Masters and Doctoral academic program is being planned for the spring 2004 academic year. Simultaneously a campus wide research program is being designed to take advantage of our portable water treatment technology expertise. These resources are available to independent operators through the SWC.

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Environmental & Regulatory Issues with Recycled Oil Field Produced Water

- David B. Burnett GPRI
- Department of Petroleum Engineering
- Texas A&M University
- Faculty Group: Fresh Water Resource Technology

- 979 845 2274
- http://www.gpri.org

Presentation Based on Final Report

Stripper Well Consortium Meeting, November 12, 2002

Fresh Water Resource Technology

- Co Sponsoring Agencies
  - Texas Water Resources Institute (TWRI)
    - *Texas A&M Initiative for Water Management Resources Technology in Oil & Gas Production*
  - Stripper Well Consortium (SWC)
    - *Environmental & Regulatory Issues with Recycled Oil Field Produced Water*
  - New York State Environmental Development Agency (NYSERDA)
    - *Co-sponsor with SWC*
  - Ground Water Protection Council (GWPC)
    - *Ensuring protection of ground water resources from contamination*
- Industry Partner
  - Global Petroleum Research Institute (GPRI)
- Governmental Agency
  - Texas Railroad Commission Chairman Michael Williams

Does Produced Water have Value?

- Can the water be treated economically?
  - Impurities removed
  - Salinity removed
  - It's a lot easier than refining crude oil
- What can the water be used for?
  - Agriculture, watershed augmentation
  - Landscaping, Livestock Watering
  - Artificial Wetlands, Habitat Restoration
  - Rangeland Recovery
- Is the water environmentally safe? What Permits are Needed?
- Is there a method that will allow the water's value to be realized?
  - Sell or trade the water
  - Recover the cost of treatment
  - Tax Incentive to help rural sustainability

Proving that Produced Water is a Resource & not a Pollutant

- Step 1:
  - Designing Water Treatment to achieve acceptable fresh water quality.
- Step 2:
  - Developing a Water Reuse Program to utilize the water in beneficial manner.
- Step 3:
  - Monitoring to Ensure Environment is not harmed. Working to Change Laws and Limitations
- Step 4:
  - Realizing Water as Value for the Community

The Four "Big Steps" to A Successful Project

- Step 1: StepBrine Desalination Process 1
  - Water Treatment to remove contamination and desalinate the brine
- Step 2:
  - Regulatory Reform to encourage projects to utilize the water in beneficial manner. A&M SWC Project Step 2
- Step 3: Step 3
  - Monitoring to Ensure Environment is not harmed.
- Step 4: Step 4
  - Realizing Water as Value for the Community

Objectives of A&M SWC Project

To identify the constraints to oil and gas production caused by inappropriate environmental and regulatory requirement and

Identify the regulatory agencies and *areas of overlapping regulations or conflicting regulation*

To act as a change agent and work with appropriate agencies to write new guideline

To establish a program to modify the regulatory practices

To report to the consortium on the progress of the program.

To provide a focal point for a coordinated effort to effect change.

Stripper Well Consortium Project Deliverables

Reports and Briefings on current regulatory practices in Eastern U.S. (West Virginia, Pennsylvania, and New York) and in Western U.S. (Texas, Oklahoma, New Mexico, Wyoming).

Progress reports and briefings on communications with regulatory agencies.

Reports and briefings to describe a program to modify the regulatory practices

Delivery of a Directory of Regulatory Information for the benefit of members of SWC. A&M will maintain and update the Directory.

Results of the SWC Project

- Created Collaboration of Experts in Technology for On Site Water Treatment and Conversion to Fresh Water.
- Designed hypothetical field project and demonstrated use of the technology to recover fresh water from produced brine.
- Addressed the permitting process required to implement field project.
- Planned implementation of the new technology in field applications.
- Obtained endorsements of regulatory officials to work to get program to field operations.

Produced Water Processing & Re-Use: Regulatory Issues

- Federal Clean Water Standards apply to any waters discharged from Oil & Gas Operations
  - oil field produced brines contain hazardous chemicals
  - In Texas, no standards have been established for the treatment of produced brines.
  - Oversight responsibilities lie with different departments within EPA
  - No standards have been established for monitoring.
  - Finally, the public perceives produced water as a pollutant, not a resource.

Summary of EPA Water Regulations

- Underground Injection
  - Stewardship Shared by State and Federal Agencies
  - Advisory Group: GWPC (Ground Water Protection Council)
- Surface Use
  - Driven by Western States Coal Bed Methane (CBM) Programs

References:
U.S. EPA Handbooks (www.epa.gov/safewater
GWPC Handbook (ALL Consulting Inc., Tulsa OK.)

EPA Derived Resouces and Action Programs

- State Generated Source Water Assessments
- State Drinking Water Funds
- Wetland Protection Programs
- Source Water Petition Program
- Water Conservation Planning Programs
- Source Water Protection Program
- State Underground Injection Program

EPA Underground Injection Control Programs

State Controlled Programs

New Mexico, Texas, West Virginia, Wyoming

Joint State/EPA Programs

Colorado, Indiana

Federal Programs

Pennsylvania, New York, Virginia

www.epa.gov/safewater

State of Texas Oil Field Cleanup Program

- Six on-going reclamation projects have been identified.
- Salt water intrusion into fresh water resources indicates that there is an opportunity to intervenes, recovery fresh water on site and reduce the volume of salt water that must be hauled away.
- EPA regulations apply to these projects with the production of oil and gas because the project is protecting drinking water sources.

Planning for Permits – All States

- Recommendations
  1. Adhere to National Standards for Clean Water
  2. Plan for public discourse
  3. Identify Key Issues and Address them
  4. Establish independent Auditing Function
  5. Use the Precepts of Sustainable Development in Project Development.

Permits for Field Project: Texas

- RRC Land Treatment Permit – Current Restrictions:
  - Isolated from Ground Water
  - Not subject to flooding
  - Not subjected to erosion
  - Minimize release of pollutants to off-site water, lands or air.
- Texas Natural Resources Codes
  - Announcements in Newspaper –"Commercial Surface Disposal Facility Permit".
  - Public Meeting (subject to Commission's requirements)
- Liability
  - Not defined.

SWC Contact List: Categories

Name and Current Position

Organization

Location

Specialized Interests

Contact Information

Total contact list (10.01.02)= 281 entries

Contact List: Agencies and People

Academic Programs - 55

Texas A&M, U. of Tulsa, New Mexico Tech

Government Agencies and Contacts -95

BLM, DOE, EPA, USGS

Industry Consultants -21

Vendors - 20

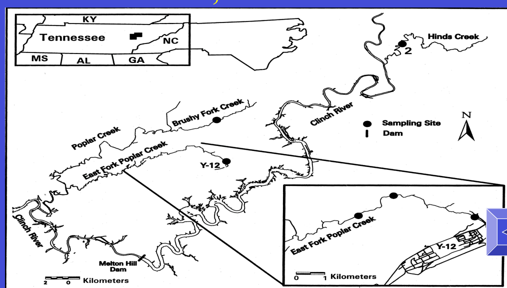
Oil & Gas Operations - 91

Total contact list (10.01.02)= 281 entries

Environmental Monitoring

- Measuring the Impact of the use of recycled oil field produced water on rangeland, wildlife, and habitats.
- Analytical testing of input and output water from modules.
- Baseline monitoring program of the environment
- Measurement of rate of habitat restoration.
- Environmental toxicology oversight of program
- Ultimate goal is to show recycled, produced water is not harmful to the environment and does not cause a buildup of harmful chemicals in wildlife.

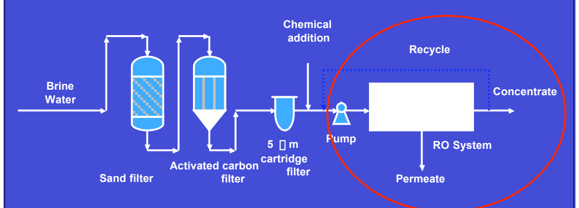
Example: Environmental Monitoring Site, Tennessee

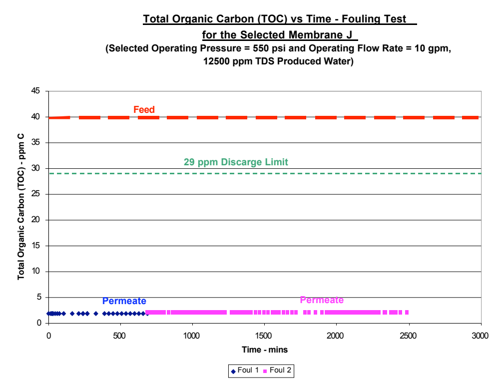


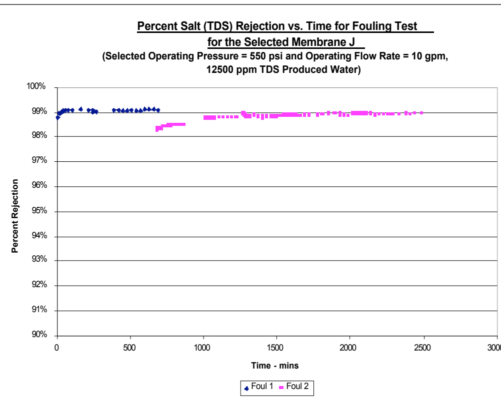
"Recommended Covenants for Produced Water Re-use"

1. Plan Project to improve environment, not just to comply with permits.
2. Seek project development from local communities
3. Look for economic market incentives to repay the extra cost of going beyond environmental compliance.

Brine Desalination Process







Produced Brine: Before and After Samples

Prod. Water Flow Rate	14000 gpd (9.72 gpm)								6000 gpd (9.72 gpm)							
Treated Water (Permeate) Flow Rate	7000 gpd (4.86 gpm)								3000 gpd (2.08 gpm)							
Total Capital Investment	95,000 $								75,000 $							
TOC before Organoclay	30 ppmC				80 ppmC				30 ppmC				80 ppmC			
Unit Life (years)	**3**	**5**	**7**	**10**	**3**	**5**	**7**	**10**	**3**	**5**	**7**	**10**	**3**	**5**	**7**	**10**
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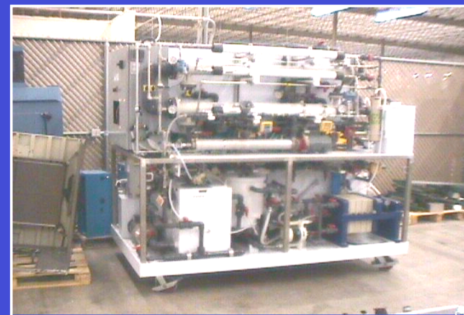
Operation Cost ($/gal perm.)	0.0074	0.0074	0.0074	0.0074	0.0107	0.0107	0.0107	0.0107	0.0086	0.0086	0.0086	0.0086	0.0119	0.0119	0.0119	0.0119
Total Water Cost ($/gal perm.)	***0.0198***	***0.0148***	***0.0127***	***0.0111***	***0.0231***	***0.0182***	***0.0161***	***0.0145***	***0.0314***	***0.0223***	***0.0184***	***0.0155***	***0.0348***	***0.0256***	***0.0217***	***0.0188***
Capital Cost ($/bbl perm.)	0.5205	0.3123	0.2231	0.1562	0.5205	0.3123	0.2231	0.1562	0.9589	0.5753	0.4110	0.2877	0.9589	0.5753	0.4110	0.2877
Operation Cost ($/bbl perm.)	0.3109	0.3109	0.3109	0.3109	0.4511	0.4511	0.4511	0.4511	0.3614	0.3614	0.3614	0.3614	0.5016	0.5016	0.5016	0.5016
Total Water Cost ($/bbl perm.)	***0.8315***	***0.6233***	***0.5340***	***0.4671***	***0.9717***	***0.7635***	***0.6742***	***0.6073***	***1.3203***	***0.9368***	***0.7724***	***0.6491***	***1.4605***	***1.0770***	***0.9126***	***0.7893***

Total Water Cost (7,000 gpd)
($/gal fresh water.) ***0.02***
($/bbl fresh water) 0.83

Total Water Cost (3,000 gpd)
($/gal fresh water.) ***0.03***
($/bbl fresh water) 1.32

Portable filtration unit donated to Texas A&M by Koch Micromembrane Filtration Services Inc.



Step 1

Step 4: Realizing Water to Value for the Community

1. Creation of a Community- Industry Dialog
2. Developing a model for water use and its value to the community.
3. Identifying Incentives for Producers to Treat Water and Provide it for Community Needs

Rangeland and Habitat Restoration using Rainfall Augmentation

Yates Ranch and Pecos River

Rangeland and Habitat Restoration using Rainfall Augmentation

Mason Wildlife Management Area Test Plot

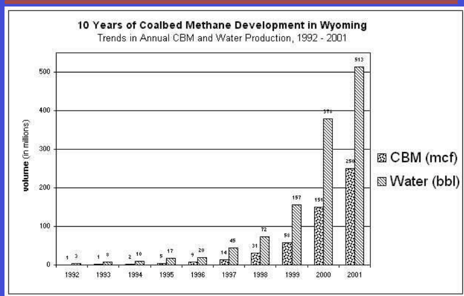
Rangeland & Grassland Rehabilitation

Texas A&M Agriculture Extension Service and Research has long offered special expertise in rangeland management.

Microenvironment Creation for Site Remediation:

- **2 to 3 acre sites used for field demonstrations**
- **1 inch water per month avg. for 8 months**
- **Decreasing EC soil readings to less than 40**
- **Reestablishing salt grass seedlings**
- **Providing nutrients for wildlife and natural grass reestablishment.**

Water Production from CBM Development in Wyoming



BLM Rangeland at Risk: Powder River Basin

Step 4: Intervention for Rural Community Development

TRAVERSE CITY - U.S. Rep. David Bonior would boost the economy and protect the environment at the same time if he were elected governor, he told an environmental Group Wednesday. (**January 17, 2002**) He touched on several environmental issues of concern to this region, including the South Fox Island land swap, slant drilling for natural gas under the Great Lakes, commercial bottling of groundwater and developmental sprawl.

Also, the number of water bottling plants is growing in Michigan and said they should be limited.
"They suck up water from our aquifer," he said. "We're losing the aquifer water we need to have an agricultural economy."

Future Activity – A&M Produced Water Treatment Program

- **Firm up Industry Participation in produced water treatment program**
- **Finalize module design and performance specifications.**
- **Select first field treatment site**
- **Create research program in sensor technology adaptable to automated, remote field operations.**

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Thank You!